Alaska Battery/Diesel Hybrid System Modeling

Presented To:

DOE Energy Storage Systems Peer Review

Arlington, VA

November 14, 2001

Presented By:

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Conclusions

- We have developed a user-friendly screening tool to determine the feasibility and desirability of installing a battery/diesel hybrid generating system in remote villages
- Analyses utilizing the screening tool indicate:
  - Battery/diesel hybrid systems can reduce fuel consumption in small rural Alaskan villages by over 20%
  - Such systems make economic sense under several scenarios:
    - When a village has a smaller, unused genset that can be retrofitted with a battery system
    - When the existing genset needs to be replaced
    - When storage tanks need to be replaced

Outline

- Motivation
- Objective
- Work Completed
- Demonstration
- Preliminary Results
- Conclusions
- Future Work
- Contributors

Motivation

- High electricity prices in rural Alaskan villages
  - High diesel fuel costs
  - Even higher maintenance costs
  - Currently subsidized under Power Cost Equalization Program
- Aging diesel storage tanks starting to leak
- Energy security

Both the State of Alaska and rural electric utilities are looking for solutions to reduce the fuel consumed to generate electricity.

Objective

Phase I: Assess the impact of integrating battery energy storage with conventional diesel-generator power systems located in remote U.S. villages (early work co-funded by USAID)

Work Completed

Phase I

- Identified candidate villages
- Obtained load data (Chistochina and Selawik)
- Identified two operating regimes:
  - – Peak Shaving – reduce diesel size, meet peaks with battery
  - – Cycle Charging – run diesel at more efficient full loading
- Developed spreadsheet model
  - – Simulated operation of hybrid system on load data
  - – Predicted fuel savings and life cycle costs
  - – Peak shaving only

Work Completed

Phase I – Results

- Significant fuel savings possible (>10%)
- Economics unfavorable at existing fuel prices and component costs

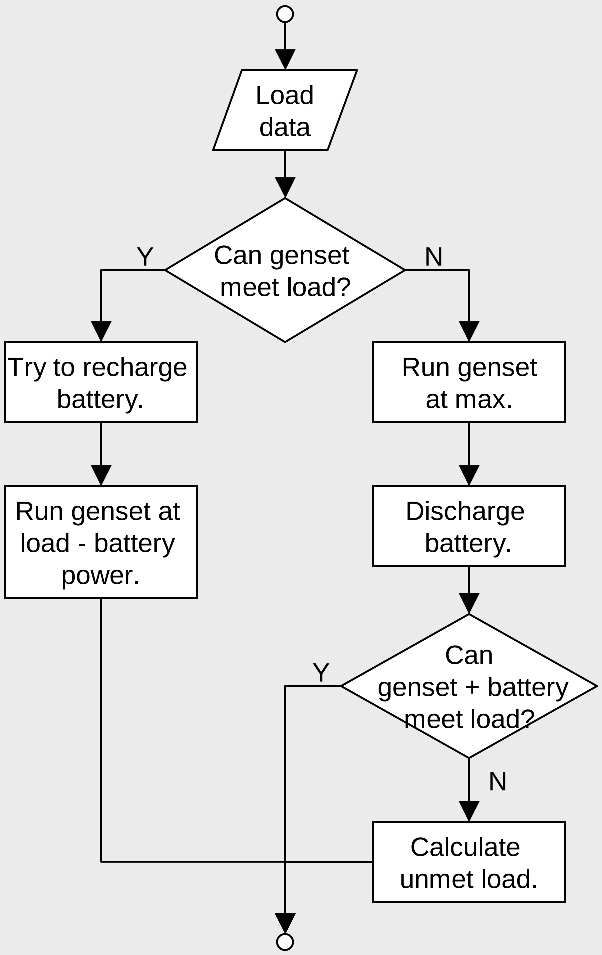
Phase I – Responses

- Relied on user intuition for battery system design, resulting in oversized battery banks
- Alaskan stakeholder feedback:
  - Add environmental metrics
  - Simplify user interface

Objective

Phase II: Develop a user-friendly screening tool that analyzes the performance and economics of battery/diesel hybrid electricity generating systems for remote villages

Flowchart – Peak Shaving



Work Completed

Phase II

Converted model from Excel spreadsheet to Visual Basic for Applications program:

- Simple, interactive user interface
- Clearly formatted output reports (Excel spreadsheets)
- Flexible inputs to allow for range of user experience levels
- Multiple load data formats
- Optimized, more accurate code

Work Completed

Phase II

Added features:

- Cycle Charge algorithm
- Economic parameters
  - Diesel Operation and Maintenance (O&M) Costs
  - Projected life for battery and diesel based on duty cycle
- Automatic PCS sizing
- New decision-making metrics
  - Unmet load indicator
  - Payback period
  - Avoided emissions
- User Manual

Preliminary Results

Chistochina, AK Analysis Key Inputs:

- Load Characteristics:

	June 1998	November 1998
Mean:	29 kW	44 kW
Maximum:	84 kW	65 kW

- Fuel Price: $0.85/gallon – located on highway
- Battery System Costs: $200/kWh + $50/kWh B.O.S.
- PCS Costs: $400/kW

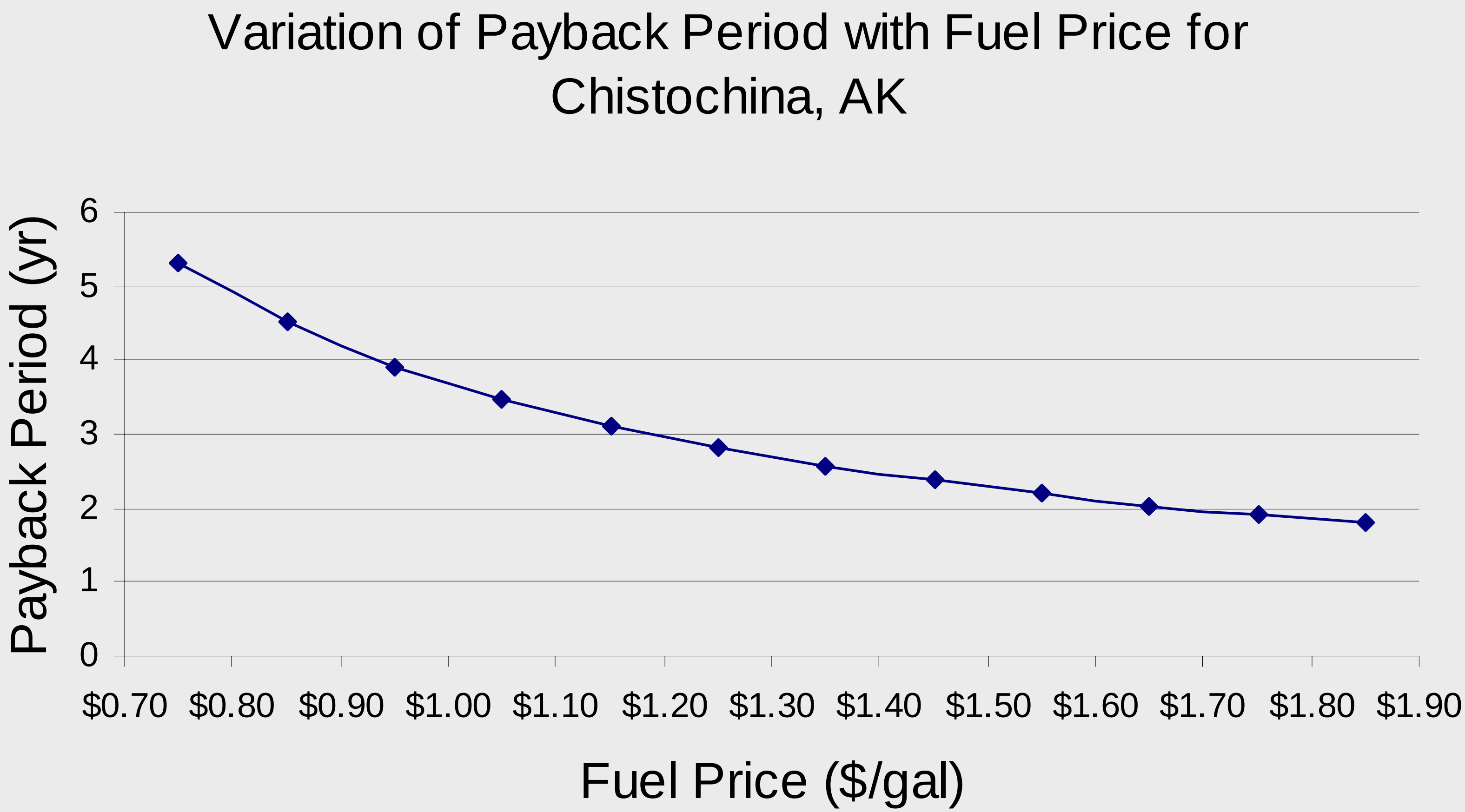
Preliminary Results

Case 1: Retrofit existing, smaller unused diesel

- Baseline Diesel: 100 kW
- Hybrid Diesel: 60 kW
- Battery Bank: 20 12V 55Ah series-connected VRLA modules
- PCS: 28 kW parallel connected Inverter/Rectifier
- Dispatch Algorithm: Peak Shaving

Output	June 1998	November 1998
Fuel Savings (%)	16.0%	14.2%
Annual Fuel Savings (gal/yr)	4,555	4,557
Net Annual Savings ($/yr)	$3,184	$3,185
Payback Period (yr)	4.5	4.5

Preliminary Results



Based on an existing 60 kW diesel which is retrofit with a 240V 55Ah battery energy storage system that is run in a peak shaving regime; payback period calculated from savings as compared to operation of baseline 100 kW diesel

Preliminary Results

Case 2: Existing diesel generator in need of replacement

- Baseline Diesel: 85 kW
- Hybrid Diesel: 45 – 60 kW
- Battery Bank: 13.2 – 20.4 kWh
- Dispatch Algorithm: Peak Shaving

Diesel Size (kW)	60 (retrofit)	55	50	45
Battery Size (kWh)	13.2	15.8	19.2	20.4
Fuel Savings (over 85 kW diesel)	10.6%	12.7%	14.6%	16.3%
Projected Battery Life (yr)	7.0	5.9	2.2	1.0
Net Annual Savings ($/yr)	$4,407	$2,505	$1,532	$1,549
Payback of Net Hybrid Investment (yr)	Immediate	0.75	2.2	1.4

June 1998 load data from Chistochina, AK

Preliminary Results

Case 3: Storage tank replacement

- Baseline Diesel: 100 kW
- Hybrid Diesel: 45 – 60 kW
- Battery Bank: 13.2 – 20.4 kWh
- Dispatch Algorithm: Peak Shaving
- Storage tank replacement costs: $6.90/gal (AEA low estimate)

Diesel Size (kW)	60 (retrofit)	55	50	45
Battery Size (kWh)	13.2	15.8	19.2	20.4
Fuel Savings (%)	16.0%	17.9%	19.7%	21.3%
Reduced Storage Needs (gal)	4,555	5,104	5,612	6,078
Net Annual Savings ($)	$5,925	$4,318	$3,685	2,314
Payback of Net Hybrid Investment (yr)	Immediate	2.2	1.9	1.2

June 1998 load data from Chistochina, AK

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Future Work

- Demonstrate to Alaskan stakeholders and obtain feedback
- Utilize data from villages for model validation and improvements
- Add renewable generation (PV, possibly wind and/or hydro)
- Aid in selection of a demonstration site
- Develop Specification Libraries
- Add battery system optimization routine
- Perform a market analysis for diesel/battery hybrid systems in Alaska

Future Work

- Other issues to consider in future versions:
  - Partial SOC cycling
  - Battery O&M costs (to account for flooded batteries)

Contributors

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  - Paul Butler
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